



Urban sprawl and climate change: A statistical exploration of cause and effect, with policy options for the EU[☆]

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ARTICLE INFO

Article history:

Received 24 October 2007

Received in revised form 15 March 2009

Accepted 17 March 2009

Keywords:

Climate change caused by sprawl
Emissions trading in land-use policies
Transport CO₂ emissions
EU policy options
Parking policy
Sprawl
Greenhouse gas emissions of cities
Emissions trading
Emissions trading in transport

ABSTRACT

This study provides a brief evaluation of the relationship between trends in transport emissions and urban land-use by analysing correlation between transport CO₂ emissions data, GDP and population data with land-use change data from the CORINE database for EU Member States between 1990 and 2000.

It concludes that the correlation between transport CO₂ emissions and the increase of artificial land area is much stronger than the correlation between CO₂ emissions and GDP or population data. The paper argues that this correlation is a strong justification for using land-use based policies to reduce CO₂ emissions.

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Summary

The EU should get involved in regulating the growth of cities. The great impact of sprawling urban development on greenhouse gas emissions makes this inevitable. Governments cannot afford to watch idly as the hard-earned gains in reducing emissions elsewhere are obliterated by cities built to require ever greater car use.

The growing demand for urban, car-based transport is a main driver in the growth of transport emissions. As the ever greater demand for automobile use is rooted in the car-centric way cities are being built today, these emissions cannot be checked alone by technical solutions that reduce per-kilometre CO₂ emissions. As people want maximum comfort, this can only be achieved by building cities where not having a car is an advantage, not an impediment.

Urban planning is no longer just a local or national issue, its impact on climate change makes it a matter for the EU to regulate. It is also clear that in most places, local governments are unable to prevent an ever greater sprawling of cities. The objective of regulation should be to make sure that new urban development is not

exclusively car-oriented, thus minimising the increase of transport-related greenhouse gas emissions. EU-level regulation may be done through establishing minimum standards of certain indicators, but emissions trading with the participation of parking space providers is also a possible method of controlling transport emissions and at the same time ensuring that future urban development is not exclusively car-oriented.

This study provides a brief evaluation of the relationship between trends in transport emissions and urban land-use. It concludes that the growth of transport emissions is a result of specific urban planning and land-use policies (or their absence). These policies can cause an increase in transport emissions even if the population size remains the same and there is no economic growth. This implies that governments need to implement sensible land-use policies. Such policies may not be very visible, but they have a huge impact on transport emissions.

Finally, the study outlines a few possible measures that could control transport emissions by addressing land-use issues. It explores ideas related to benchmarks, mandatory plans and the possibility of using the concept of emissions trading in connection with land-uses causing transport emissions.

What causes the growth of transport emissions? A statistical analysis

In 2005, transport emissions accounted for around 20% of all GHG emissions in the EU-25. Road transport is responsible for 93%

[☆] The views expressed in this article are purely those of the writer and may not in any circumstances be regarded as stating an official position of the European Commission.

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Table 1Change of road transport CO₂ emissions and possible explanatory variables between 1990 and 2000 for selected EU Member States.

Country	Percentage change between 1990 and 2000			
	Road transport CO ₂ emissions ^c (%)	Artificial areas ^d (%)	Per capita GDP ^e (%)	Population ^f (%)
Austria	37.92	3.06	22.98	5.08
Belgium	20.85	2.78	^a 20.32	2.85
Denmark	15.77	4.31	24.42	3.86
France	17.80	4.84	16.42	4.13
Germany	10.57	5.80	18.90	^b 2.72
Greece	25.68	13.82	^a 19.34	8.21
Hungary	6.04	1.51	^b 24.20	−1.57
Ireland	106.30	30.67	^a 82.99	8.19
Italy	17.65	6.13	16.58	0.80
Netherlands	24.46	22.42	28.21	6.52
Poland	11.60	1.44	^a 44.09	0.59
Portugal	85.20	38.64	^a 29.92	3.61
Spain	46.45	25.14	^a 27.69	3.64
United Kingdom	6.42	1.87	24.83	2.88
Total of these countries	18.59	6.62	26.82	2.86

^a Using OECD's estimate for 1990 per capita GDP value.^b Using 1991 value instead of 1990.^c Based on data from OECD and the European Environmental Agency.^d CORINE Land Cover Database (European Environmental Agency).^e Real gross domestic product (expenditure approach), per head, US \$, constant exchange rates (source: OECD).^f (Source: OECD).

of all transport emissions, emitting about 900 million tons of CO₂ in the EU-27 in 2005. This is almost half the amount of emissions covered by the EU ETS. Urban transport accounts for half of these emissions, which brings their annual volume close to the Germany's annual emissions under the EU Emissions Trading Scheme.

Since 1990 transport emissions have increased by one-fifth, which is the largest increase among all emitting sectors. The trend in both the absolute and the relative increase of transport emissions is not expected to change in the future. According to the EEA by 2010, EU-15 greenhouse gas emissions from transport are projected to increase from the current 126% of 1990 levels to 135% if only existing policies and measures are used. Even with the recently adopted 120 g CO₂/km limit on car emissions, transport emissions would still increase with 27% over 1990 levels.¹

The immediate cause of the phenomenal growth of transport emissions is clear: (a) People are travelling more and more in general, and especially more on roads. In the EU-25, the number of road-passenger kilometres increased 26% between 1990 and 2000², i.e., much higher than the 20%³ increase in GDP in this period. The number of cars has also increased by 35% in this period, approaching an average of four cars to 10 people in the EU-15. (b) Demand for the transportation of goods (responsible for about a third of transport emissions) increased even faster in the same period, with the number of road-freight tonne kilometres growing with 36%.⁴ This strong increase is somewhat mitigated by an increase of efficiency in fuel use, as CO₂ emissions from road transport have only increased with 18%.

We need to ask then: what causes the increase in the transportation of passengers and goods? In the current paper, we will look at the development of different general factors in EU Member States for the 10-year period between 1990 and 2000, and will try to assess their impact on road transport emissions through statistical anal-

ysis. We will seek to determine (a) whether there is a meaningful correlation between a particular indicator and road transport CO₂ emissions; and (b) whether it is possible to establish a clear cause-and-effect relationship between this indicator and road transport CO₂ emissions. The analysis will cover population, gross domestic product and artificial land area. Technological improvements in vehicle efficiency are not considered as they are known to show a gradual and steady increase that is largely uniform in all Member States, and thus it cannot have a strong explanatory power.⁵ The analysis will be restricted to road transport, leaving aside aviation, rail transport and shipping (together responsible for less than 10% of transport emissions.) These transport modes are not much used in everyday passenger transport or in retail freight, and the relationship of their emissions to changes in the land area covered by buildings and roads is probably not relevant.

We analyse the relationship between changes in the above-mentioned variables and changes in road transport emissions for EU Member States where data is available. We use a simple linear multiple regression analysis to determine the relationship between the change in population, gross domestic product and artificial land area and the change in road emissions between 1990 and 2000. The method of analysis assumes that the same relationship holds true for all countries in Europe. The data analysed was expressed in terms of percentage change, so that the effect of the size of the countries would not appear in the analysis. The data used for the analysis is presented in Table 1 (all graphs in the text are based on this dataset).

The analysis shows that the three variables explain to a considerable degree the variation in the increase in road transport emissions. The R² of the linear regression is 85.1%, the adjusted R² is 80.6%, and artificial land and per capita GDP variables are significant variables. We present the results of the analysis in more detail below. If the insignificant population variable is left out of the regression, the R² is 84.74% and the adjusted R² is 82.0%.

¹ EEA report no. 9/2006, Greenhouse gas emission trends and projections in Europe 2006, pp. 39–40.

² Based on data in "Cutting Transport CO₂ emissions: what progress? (OECD, January 2007).

³ Based on OECD, 2007.

⁴ Based on OECD, 2007.

⁵ See, e.g., EEA, Average specific CO₂ emissions of new passenger cars per fuel type and targets, (<http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=2465>).

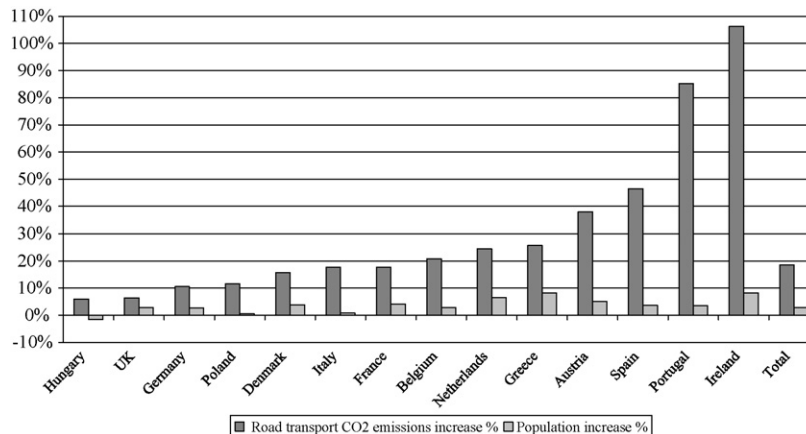


Fig. 1. Comparison of road transport CO₂ emissions increase and population increase between 1990 and 2000.

Population

As more people travel more and also demand a greater quantity of products to be transported, there is a clear cause-and-effect relationship between road transport CO₂ emissions and population increases. (By contrast, it would not make sense to suppose that the population is growing because people and goods are travelling more.)

The overall population figures are fairly stable in Europe. Between 1990 and 2000, the population of the EU-25 has increased with less than 3%. The variation among countries is modest, with Ireland and Greece showing an 8.2% increase and Hungary a 1.5% decrease over the period.

Fig. 1 compares the growth of transport CO₂ emissions with population growth in selected countries. In some countries (e.g., Ireland), a higher than average population growth took place simultaneously with a strong increase of road transport-related emissions. For example, both Greece and Ireland saw its population increase by over 8 per cent, but the growth of transport emissions in Greece was one-quarter of the growth seen in Ireland. At the same time, countries like Portugal and Spain have experienced an explosion in transport emissions while population increase remained slightly over the average.⁶ It is also clear from multiple regression analysis that population growth in itself cannot explain the increase in transport emissions. According to the analysis, the growth of population does not contribute significantly to explaining the variance of the growth of CO₂ emissions. A multiple regression analysis of the relationship between road transport CO₂ emissions and population growth, per capita GDP growth, and increase of artificial areas yielded a *t*-value of 0.48 for population growth, and a *p*-value of 0.63.

The lack of a strong relationship between population and road transport CO₂ emissions is also apparent from Fig. 2 which shows the evolution of per capita road transport CO₂ emissions. Remarkably, this means that often the same number of people are able to travel more and/or consume goods requiring a greater amount of transportation than before. But exactly how much more depends largely on some other variable.

Gross domestic product

It is generally considered that the volume of transport and thus road transport CO₂ emissions are related to GDP, i.e., the richer a country is, the more transport would take place. The establishment of a cause-and-effect relationship is not straightforward, however. It is equally sensible to suppose that people are getting richer and therefore they travel more and buy goods with a greater value (acquired through more transport), or that by more transportation of goods and people, the economy becomes more productive and generates more GDP.⁷ Therefore, GDP growth and the growth of transport emissions are not necessarily in a single cause-and-effect relationship, but rather may influence each other.

In the whole EU, transport-related CO₂ emissions have grown in tandem with per capita GDP. This statement masks great differences in the evolution of transport emission-related per capita GDP intensity between individual Member States. Fig. 3 compares the growth of per capita GDP with the growth of road transport-related CO₂ emissions. As we can see, some Member States have experienced high per capita GDP growth coupled with high growth in road transport-related CO₂ emissions (Ireland). Some Member States had seen an enormous growth in road transport-related CO₂ emissions, but per capita GDP growth was only slightly above average (Portugal, Spain). Finally, there are countries where an average per capita GDP growth was attained with a relatively little increase in road transport-related CO₂ emissions (UK, Poland, Germany).

The multiple regression analysis showed that per capita GDP contributes little to explaining the growth of CO₂ emissions. A multiple-style regression analysis of the relationship between road transport CO₂ emissions and population growth/per capita GDP growth/increase of artificial areas yielded a *t*-value of 2.7 for per capita GDP growth, with a *p*-value of 0.02. If the insignificant population variable is left out of the analysis, the *t*-value is 2.9 and the *p*-value is 0.01. The coefficient of the variable is 0.6, which means that a 1% rise in per capita GDP produces less than 1% rise in transport CO₂ emissions.

This shows that road transport emissions are to some extent linked to economic growth. If the cause-and-effect relationship

⁶ It should be noted however that while Spain and Portugal did not experience significant overall population growth, there is a very strong urbanisation trend in these countries, i.e. people are moving to the big cities. (See: page 15, EEA Report no. 10/2006). This movement in itself does not have to lead inevitably to increasing transport emissions – it does so probably because new urban areas are built in a sprawling, transport-intensive fashion.

⁷ The fact that a growth in transport infrastructure investment induces economic growth has been supported by early works by, e.g., Aschauer (1989), but recently several authors have refuted this claim. Crescenzi and Rodriguez-Pose (2008) have conducted an analysis of data for European countries which shows that although good infrastructure endowment is a precondition for high economic performance, additional investment in infrastructure is disconnected from economic performance.

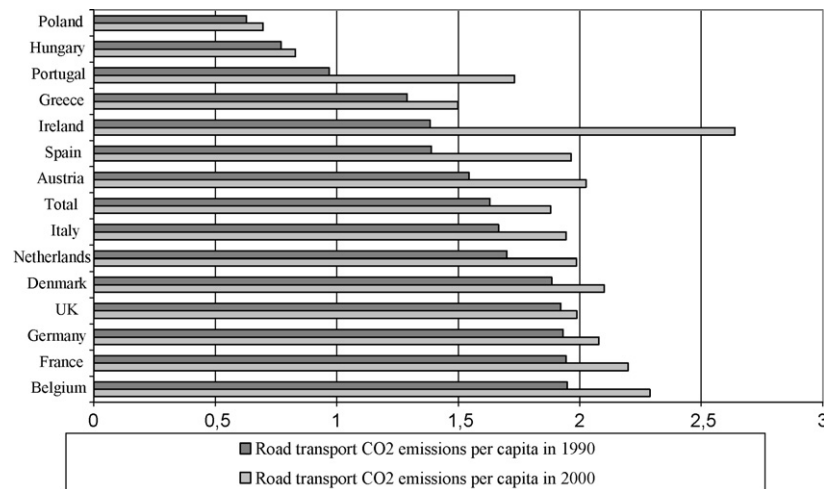


Fig. 2. Road transport CO₂ emissions per capita in 1990 and in 2000 (tons).

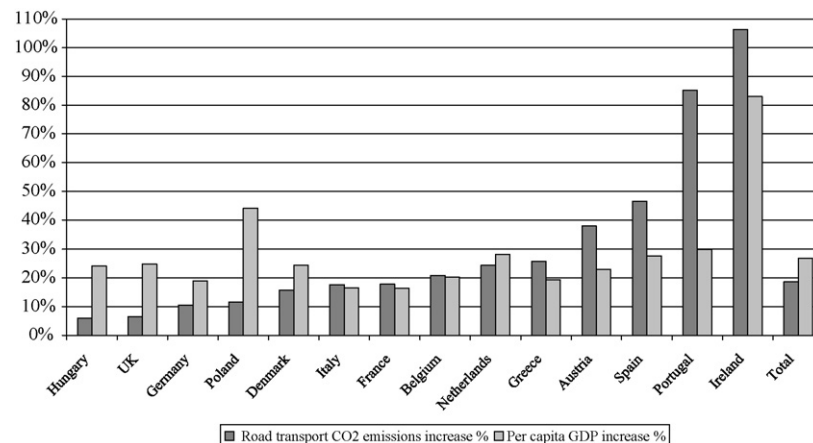


Fig. 3. Comparison of road transport CO₂ emissions increase and GDP increase between 1990 and 2000.

shows that transport is a precondition of economic growth, we would have to conclude that the only way to stop road transport emissions from growing would be to limit economic growth, which would be very difficult for any elected government to sell. However, such a conclusion cannot be reached based on the analysis of this paper, and recent literature seems to indicate that the relationship may not be as straightforward as previously thought. Transport-related CO₂ emissions and economic growth may reveal that some stages and types of economic growth do correlate with rising emissions while others not, but further analysis would be necessary to support this conclusion.

In wealthy countries where the motorway network is already built, with little space for new roads and everybody who wanted a car already has one,⁸ further economic growth may not necessarily be linked to greater transport volumes (UK, Sweden), and transport emissions could increase slowly on an already high base. In countries where the motorway network is in the process of being built and many people cross the wealth threshold necessary to buy a car, economic growth may be accompanied by a massive increase

in transport emissions from a lower base⁹ (Portugal, Ireland). Such analysis is beyond the possibilities of the present paper, however.

Increase in areas covered by buildings

If population growth and economic growth cannot of itself explain growth in transport emissions, we must look for other causes to explain greater road transport emissions. We have seen that transport emissions increase because there is a greater quantity of passenger kilometres and freight tonne kilometres. The increase in these values could be a result of more passengers and goods travelling between the same destinations or of the same amount of passengers and goods travelling between destinations that are further apart from each other than before.

For both goods and people, most journeys either connect two urban areas or connect two destinations within the same urban area. No reliable statistical data is available on how much of road transport CO₂ emissions is generated in urban areas. According

⁸ For a comparison of GDP levels and the number of vehicles, see European Environmental Agency, *Indicator fact sheet TERM 2002 32 AC – Size of the vehicle fleet*, p. 7. (<http://themes.eea.europa.eu/Sectors.and.activities/transport/indicators/technology/TERM32,2002/TERM.2002.32.AC.Size.of.the.vehicle.fleet.pdf>).

⁹ This hypothesis seems to be borne out by the fact that the land used for road networks has indeed increased by over 300% between 1990 and 2000 both in Portugal and Ireland, while the average increase in the EU-25 was only 21% (EEA Corine Land Cover Database). In this period, Ireland had much higher than average economic growth, while Portugal's growth was only average.

to the EC's Green Paper on Urban Transport,¹⁰ urban mobility "accounts for 40 per cent of all CO₂ emissions of road transport." OECD experts consider that the correct figure would be even higher than this.¹¹

It would require a very complex analysis to fully map the long-term evolution of trip lengths and destinations for all passengers and goods. In the following, we will try to cut through this complexity by assuming that the increase in road transport emissions can be explained by the increase in urban areas. An increase in urban areas increases individual trip lengths, and as most newly urbanised areas are fully car-dependent with no public transport, these areas would have to lead to increase road transport emissions. This assumption is well grounded in the findings of researchers (see, e.g., Camagni et al., 2002).

While this approach does not fully explain the increase in emissions that occur in interurban transport, (i.e., about 50% of road transport emissions), it could provide a strong explanation for the increase of emissions within urban areas, i.e., for the other half of the emissions, because of the clear cause-and-effect relationship between destinations and transport emissions. As people and goods rarely travel to an empty field in the hope that one day they will find a house, a shopping mall or a factory there, the establishment of a destination (and the road leading to it) *always* precedes the journeys that cause the CO₂ emissions. Indeed, the building of new roads and buildings is considered to be a primary reason for the growth in road transport also by Southworth (2001).

For analysing the increase in urban areas, the CORINE Land Cover Database was used, which uses satellite imaging to calculate the number of hectares covered with a particular land-use type. CORINE uses about 20 different land-use classes, covering different types of natural areas (forests, agriculture, wetlands, etc.) and artificial areas (continuous and discontinuous urban fabric, commercial areas, transport infrastructure areas, etc.). Data is available for 1990 and 2000 for the EU-27, except Sweden, Finland, Cyprus and Malta. To measure the increase of urban areas, CORINE's composite land-use-class of artificial areas is used. This composite includes all buildings and all transport infrastructure (with the latter being overwhelmingly roads), and in this paper we will continue to refer this group as "artificial areas".

An EEA report¹² provides a detailed analysis of the urbanisation and sprawl trends in Europe for the 1990–2000 period. According to the report, most European regions are sprawling (i.e., urban areas are expanding much more than population growth), as new housing and commercial development is almost exclusively suburban and car-centric. As these areas are usually not new cities, but rather outlying appendages to existing urban areas, the inhabitants continue to use the same city centres, but reach them from further away. With the new areas usually not planned around public transport and too thinly populated anyway to be able to support effective public transport, and the passenger car remains as the sole feasible mode of transportation. The area gobbled up by cities between 1990 and 2000 is equivalent to the entire area of Luxemburg. The advance of artificial areas is alarmingly fast in Spain and Ireland, while the process is only beginning in the new Member States. A very important finding of the report is that sprawl is not a natural phenomenon; it can be effectively controlled with the appropriate government policies. Indeed, a study by Cameron et al. (2004) concluded that "a number of cities in Europe (e.g. Munich and Stockholm) and Asia (e.g. Hong Kong and Singapore) have shown that clear policy

initiatives can contain the growth of urban private motorised mobility" and "in other cities such as Stockholm, the control of urban sprawl . . . appears to have been pivotal in reducing the growth of car use, despite strong growth in affluence and car ownership."

The question is whether the expansion of artificial areas (in short, sprawl) can be considered as a driver of transport emissions growth. The multiple regression analysis which was conducted on the change in road transport emissions between 1990 and 2000 also included the change in the land covered by artificial areas as an explanatory variable. The result is that the relationship between the growth of artificial areas and the growth of transport CO₂ emissions is very strong, much stronger than for the other examined factors (i.e., population growth and per capita GDP growth). A multiple-style regression analysis of the relationship between road transport CO₂ emissions and population growth/per capita GDP growth/increase of artificial areas yielded a *t*-value of 4.2 for increase of artificial areas, with a *p*-value of 0.002. If the insignificant population variable is left out of the analysis, the *t*-value is 5 and the *p*-value is 0.0004. The coefficient of the variable is 16, which means that a 1% rise in per capita GDP produces a higher than 1% rise in transport CO₂ emissions.

This result is in line with the overall conclusion found in many studies that there is a strong link between the density and form of urban development and the amount of private car transport that the development entails (Newman and Kenworthy, 1999; Handy, 2005). In a particular example, Muñiz and Galindo (2005) reached a similar conclusion in their study of Barcelona when they stated that "measures of urban form typically used (net population density and accessibility) have a greater capacity to explain municipal ecological footprints variability than other factors, such as average municipal family income and the job ratio, which leads the authors to conclude that urban form exercises a clear effect on the ecological footprint of transport."

Fig. 4 provides a percentage comparison between the increase of artificial land and road transport, as it was done earlier for population and per capita GDP. There are great individual differences between Member States in the rate of sprawl they are experiencing. It has barely started in the new Member States, and it has reached dramatic proportions in Spain, Portugal and Italy. However, where sprawl is strong (e.g., artificial areas have increased with more than 5% from 1990 to 2000), there was also a significant increase in road transport emissions (with the exception of the Netherlands). Similarly, the increase in road transport emissions was the lowest in the countries experiencing the least degree of sprawl.

Summary

The strong correlation between transport-related CO₂ emissions and the clear cause-and-effect relationship between the development of artificial land and the ensuing increase in transport-related CO₂ emissions indicates that policies to stop or limit the increase of CO₂ emissions in transport should aim at limiting the increase of artificial land. Such policies may not necessarily have to restrict economic growth, as that is possible without increasing the quantities of artificial land.

Sprawl is not an inevitable consequence of economic growth, but rather a result of specific government policies. The economy of the Netherlands and Portugal increased at about the same rate between 1990 and 2000, but Portugal saw both its urban area and transport CO₂ emissions grow at triple the rate of the Netherlands. This difference can probably be best explained by different land-use policies. Another example is the UK, which had strong economic growth in this period but very little sprawl, probably due to its vigorous policies against sprawl. According to Couch and Karecha (2006): "urban sprawl in Britain is brought under strong planning control and

¹⁰ COM (2007) 551 final, Green Paper: Towards a new culture for urban mobility, Brussels, 25.9.2007, p. 3.

¹¹ Source: personal interviews.

¹² Urban sprawl in Europe, the ignored challenge, EEA Report No. 10/2006.

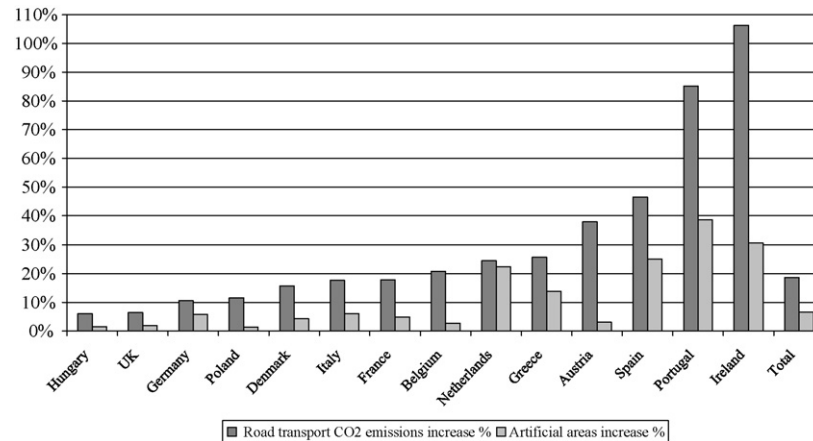


Fig. 4. Comparison of road transport CO₂ emissions increase and artificial areas increase between 1990 and 2000.

this has been particularly effective in the large northern conurbations such as Liverpool.” As the newly urbanised areas are a primary cause of increasing transport CO₂ emissions, the current insouciance of EU-policies towards increasing sprawl is a dangerous position that threatens to undermine the achievements of other climate policies.

The CO₂ emission effects of unmitigated sprawl are already clearly visible in the Mediterranean Member States. For example, although under the EU burden sharing agreement Spain is allowed to increase its total greenhouse gas emissions by 15% compared to 1990 levels by 2008–2012, in 2005 its total emissions stood at 50% over the base year. Though emissions from all sectors are growing, transport emissions have almost doubled in Spain and have increased their share in total emissions. The picture is similar in Portugal, Ireland, Greece and Italy. The Member States most affected by sprawl are among those that are furthest away from meeting their Kyoto Protocol reduction targets.¹³ All these countries will now have to spend huge amounts of money on buying credits to comply with their Kyoto target. Their transport emissions, engendered by growing affluence that allows more and more people to have cars, coupled with a lack of urban planning, will be very costly to reduce. Once people start driving a car, it is very difficult to get them out of it.

For better or worse, Central Europe always tried to follow the development patterns of Western Europe. This seems to be the case in transport development too. Greenhouse gas emissions from transport in the new Member States have increased by 28% between 1990 and 2004,¹⁴ which is higher than the average increase in the EU-15. As these countries have already fulfilled their Kyoto targets, no outside pressure will limit the growth of transport CO₂ emissions in these countries until after 2012. Due to the lack of roads and money for cars, sprawl was not strong in the land-use patterns of the 1990–2000 period in these countries. However, as they are in the process of passing the wealth threshold beyond which buying cars is available for everyone,¹⁵ we can expect to see transport emissions and sprawl to explode the same way as they did in the Mediterranean. With no EU-policies against sprawl, the deluge of structural and cohesion funds (a large portion of which is spent on new roads) will only exacerbate this process. According to an EEA

report: “The new Member States seem to be repeating the experience of Ireland, Portugal and Spain. Starting from a relatively low transport level, all these countries experienced strong growth in transport and its greenhouse gas emissions due to high economic growth.”¹⁶

In order to prevent the further deterioration of the situation in the Mediterranean and to try to set new Member States on a more sustainable course of growth, the EU should get into the business of regulating city development and urban planning. The possible policy options are outlined in the next chapter.

What could the EU do to limit the growth of greenhouse gas emissions from transport?

Current policies on reducing transport emissions

Existing and planned specific EU-level policies aim primarily at increasing the CO₂-efficiency of existing traffic volumes. Both the Directive 2003/30/EC on biofuels and the planned target of 120 g CO₂/km for new passenger cars by 2012¹⁷ would bring substantial savings in transport-related CO₂ emissions but that will only slow their growth and not stop the increase. The average carbon dioxide emissions of new passenger cars were reduced from 186 g CO₂/km in 1995 to 163 g CO₂/km in 2004, representing a reduction of about 12%.¹⁸ However, in the same period, 21% more cars were sold, more than offsetting the emission reductions due to increased CO₂-efficiency.¹⁹ As nothing indicates that the trend towards a growing automobile fleet (and a parallel increase in the growth of artificial land²⁰) would stop in the future, a similar offsetting of the planned policies can be expected.

The EU’s Green Transport package of July 2008²¹ makes an important step by providing a common framework for Member States’ policies on charging road usage by heavy lorries, and cru-

¹³ EEA 9/2006, p. 23.

¹⁷ Commission communication – review of the community strategy to reduce CO₂ emissions from passenger cars and light-commercial vehicles (7.2.2007, COM (2007) 19 final).

¹⁸ COM(2007)19 final, Impact Assessment, pp. 7, 32.

¹⁹ EEA 9/2006, p. 47.

²⁰ Not surprisingly, there is a discernible correlation between the increase of the number of passenger cars and the increase of the artificial land area. In statistical terms: R_2 (indicating the strength of the relationship)=0.7 (1 means a perfect correlation, 0 means no correlation); P -value (indicating statistical significance)=0.00000840912 (i.e., there is a 0.0008% likelihood that the correlation is “false”).

²¹ For a summary of the documents in the package, see: <http://ec.europa.eu/transport/greening/index.en.htm>.

¹³ EEA 9/2006, p. 20.

¹⁴ EEA 9/2006, p. 23.

¹⁵ The threshold appears to be being passed in these years. Car sales in Central and Eastern Europe have increased by 13.4% between 2006 and 2007, with several countries showing growth over 25%. <http://www.jato.com/Documents/PRESS%20RELEASES/Central%20and%20Eastern%20European%20car%20market%20continues%20significant%20growth%2025.9.2007.pdf>.

cially, allowing the introduction of environmental costs in the charges, something that was not possible before. However, as the Communication²² in the package states, “Private transport is not covered because of subsidiarity”. In other words, the EU does not consider itself legally empowered to introduce road charging for passenger cars, a policy that could have dramatic effects on sprawl and its related emissions.

Outside actual legislation, the notion that unsustainable land-use patterns are a main cause of the increase in transport emissions does appear in policy documents, though without offering policies to address the problem. The Thematic Strategy on the Urban Environment²³ does at one point say that “Avoiding urban sprawl through high density and mixed-use settlement patterns offers environmental advantages regarding land use, transport and heating contributing to less resource use per capita²⁴”, but it never quite makes the link between land-use decisions and climate change. The Thematic Strategy takes a broad view, with strong emphasis on the co-benefits of environmentally friendly urban policies, when it states that “Effective transport planning requires long-term vision to plan financial requirements for infrastructure and vehicles, to design incentive schemes to promote high quality public transport, safe cycling and walking and to coordinate with land-use planning at the appropriate administrative levels. Transport planning should take account of safety and security, access to goods and services, air pollution, noise, greenhouse gas emissions and energy consumption, land use, cover passenger and freight transportation and all modes of transport.”²⁵

A very useful result of the Commission's work on the Thematic Strategy is the development of guidance on Sustainable Urban Transport Plans²⁶, which provides a wealth of information on what local governments can do to reduce CO₂ emissions from transport if they have the resources to address the issue. The Annex of the guidance²⁷ provides detailed policy options in the areas of land-use and transport planning co-ordination, traffic calming, fostering cycling and walking, promoting public transport, road pricing, and parking management.

The Green Paper on Urban Transport is a document that is up to date with the latest thinking on the environmental impacts of car-traffic and identifies sensible policies to promote the use of public transport, cycling and walking. In particular, it recognises that “The trends towards suburbanisation and urban sprawl lead to low-density, spatially segregated land-use. The resulting dispersal of home, work and leisure facilities results in increase transport demand. The lower densities in peripheral areas make it difficult to offer collective transport solutions of a sufficient quality to attract substantial amounts of users.”²⁸ In other words, sprawl cannot be “fixed” by investment in public transport, it is an inherently climate-unfriendly mode of urban development, which cannot be eliminated by better transport policies – it needs better land-use policies. However, the Green Paper on Urban Transport does not go beyond asking the question: “How can better coordination between urban and interurban transport and land use planning be achieved?”²⁹

Possible future policies

From a policy development point of view, realising that sprawl is a main driver of the growth of transport emissions is a good thing as it allows policymakers to do something beyond legislating CO₂-efficiency improvements that do not reduce the volume of traffic or hoping that modest increases in fuel tax would reduce emissions without causing public outrage first.

The growth of urban areas (at steady population levels) is not a desirable public good, but rather an undesirable consequence of ever greater fossil-based mobility. Governments seek to limit sprawl, though with varying success. In the EU, as the Thematic Strategy for the Urban Environment states “Most cities are confronted with a common core set of environmental problems such as poor air quality, high levels of traffic and congestion, high levels of ambient noise, poor-quality built environment, derelict land, greenhouse gas emissions, urban sprawl, generation of waste and waste-water.”³⁰

If greenhouse gas abatement policies are aimed at limiting sprawl, they can be expected to face less opposition than policies that directly limit car use or raise fuel costs. Unlike a road that people are not allowed or cannot afford to use, a mobility need that does not emerge does not hurt anyone. Another advantage of concentrating on land-use policies is that the building of cities is already a densely regulated field, albeit the current objective of regulations is not always to limit greenhouse gas emissions.

The EU has significant limitations in developing policies on urban planning. Land-use policies are currently widely regarded as falling into national, regional or local competence, even though the climate change effects of urban planning do not justify this. Article 175 of the EC Treaty explicitly states that “measures affecting town and country planning and land-use” require unanimity. These provisions also appear in Article III-234 of the Constitution; however, internal market-related harmonisation measures will be exempted from such unanimity requirements. Tax policies are in principle possible to adopt on an EU-level, but they require unanimity. The EU's unsuccessful efforts in the 1990's to introduce a meaningful EU carbon tax practically rule out the possibility of fighting sprawl with EU-level taxes (either on fuels, vehicles or land-use types) in the foreseeable future,³¹ even though taxes could be very effective for this purpose.

As it is properly recognised by the Thematic Strategy, many European cities were successful in developing policies to halt sprawl and to limit the growth of transport CO₂ emissions. (Witness for example, the outstanding success of the policies of Dutch cities to limit the growth of transport emissions compared to increase of land area in Fig. 4.) However, as these policies are often locally initiated, only the vanguard of regional and local governments can implement them, while the majority of cities abandon themselves to the centrifugal forces of car-based urban development because of a lack of resources and/or expertise. Without central, EU-level requirements to address the problem of sprawl, most cities will only recognise it when it is too late. Bearing in mind the impending explosion of transport CO₂ emissions in the new Member States, the EC needs to stop preaching to the converted and focus on extending sustainable urban development practices through binding measures,

While there is a need for general EU-level policies in the field, it is very important to recognise the diversity of the myriad planning decisions that subsidiarity rightly places in the hands of local governments. EU-policies should avoid micro-management and

²² COM (2008) 433 final, Communication from the Commission to the European Parliament and the Council on Greening Transport, Brussels, 8.7.2008.

²³ COM (2005) 718 final, Communication from the Commission to the European Parliament and the Council on a Thematic Strategy on the Urban Environment; Brussels, 11.1.6.

²⁴ COM (2005) 718 final, p. 10.

²⁵ COM (2005) 718 final, p. 5.

²⁶ http://ec.europa.eu/environment/urban/pdf/transport/2007_sutp_prepdoc.pdf;

²⁷ http://ec.europa.eu/environment/urban/pdf/transport/2007_sutp_annex.pdf.

²⁸ COM (2007) 551 final, p. 15.

²⁹ COM (2007) 551 final, p. 16.

³⁰ COM (2005) 718 final, p. 3.

³¹ For a short account of the EU's attempts to introduce a carbon tax, see Padilla and Roca (2004).

concentrate on areas where it is possible to set up general guidelines that can be followed under all circumstances.

Following are a set of ideas on the types of instruments that the EU could develop with the purpose of reducing transport CO₂ emission through encouraging more sustainable land-use patterns. The measures presented below were selected according to the following criteria: (a) they are legal under the EC Treaty; (b) they can be adopted on an EU-level without unanimity; (c) they are not voluntary actions, but applicable for all. Ideas related to improving public transport are not included here as such measures are addressed in detail in the Green Paper.

Benchmarks, targets and minimum standards

Though urban planning needs to take account of diversity of urban areas, if the objective is to reduce CO₂ emissions, it is possible to develop overall objectives which could then be established as recommended benchmarks, future targets or mandatory minimum standards. The most straightforward would be a public transport access requirement, whereby Member States would be required to ensure that buildings have access to a certain level of public transport.³²

Though a public transport access requirement policy does not directly regulate urban development, the only way for Member States to realise such an obligation is (in addition to investing in public transport) through urban planning measures, in particular in requiring higher settlement densities. A public transport access obligation could stop the process of building low-density suburban areas where public transport is unable to compete with cars. As a minimum, the policy could extend to new apartments, larger workplaces and commercial establishments; it could then be extended to various categories of existing buildings. Similarly to recycling and renewables, the requirement could also be formulated in percentages to be reached within a timeframe.³³ A first step in this direction would be to include information on the level of public transport accessibility into all buildings' Energy Performance Certificates.

As a remnant of an age with different preoccupations, many cities have minimum parking space requirements for new buildings. This policy is intended to make sure that relatively wealthy car-owners are also able to move into these buildings thus increasing the local tax base, but it invariably has the consequence of increased congestion. Therefore, instead of minimum requirements, targets for maximum parking space requirements should be established, depending on the level of public transport available.³⁴ Such a policy would reduce CO₂ emissions, reduce congestion and free up space for other uses. (Of course, this policy works only if the area is served by public transport or is accessible on foot and bicycle.)

³² A similar policy exists in the Netherlands since the early 1990s, known as the "ABC location policy", which differentiates between areas according to their accessibility by public transport. Businesses which attract a large number of customers can only be located at places with good public transport access. (<http://international.vrom.nl/docs/internationaal/engelsesamenvattingnr.pdf>). Another comparable policy is the so-called "concurrency" policy in Florida and the US state of Washington, which requires local governments to only allow new urban development if certain public services (including e.g. public transport but also roads) is made available "concurrent with the impacts of such a development." (Southworth, 2001; Steiner, 1999).

³³ In its effects, such a percentage target could be compared to the UK target of building at least 60% of new housing on brownfields (i.e., previously developed land), which typically have better transport services than greenfields. (Couch and Karecha, 2006).

³⁴ The Dutch "ABC" location policy is again a good example of this, as it maximises the amount of parking space that can be provided for each location type, e.g., in an "A" location the ratio of total area to parking area must not exceed 1:125.

Another possible benchmark is the designation of peri-urban green areas that could eventually form an effective urban growth boundary around large cities. Most large agglomerations have already expanded well beyond the administrative limits of the original city. This often results in a situation where fight against sprawl is expected from suburban municipalities who often welcome sprawl as new housing and new businesses increase local revenues. A potential tool against this process would be to require Member States to designate no-development areas around large cities that would form a barrier towards sprawl and direct further development into existing transport corridors³⁵ and areas that are well served by public transport. Thus, such a policy is in effect the inverse of a public transport access requirement, in making areas not served by public transport off-limits to development. Unoccupied areas around cities are currently often agricultural areas that would not merit protection on the basis of their environmental value. Once such protected areas are established, they could also serve the purpose of providing accessible green areas to people living in the neighbourhood (which is necessary if they live at density levels that are high enough to maintain public transport.) According to Anas and Pines (2008), if charging for road usage is not possible, urban growth boundaries are effective second-best measures to limit sprawl.

Development of mandatory Sustainable Urban Transport Plans

Short of targets and benchmarks, the public and authorities can be made to think about the climate change impacts of their development policies through a requirement to draw up plans and strategies on sustainable urban development.

A very important recommendation of the Thematic Strategy is for cities to develop Sustainable Urban Transport Plans. This is already an obligation in France and the UK, and other Member States are considering its introduction. According to the Thematic Strategy, "Transport planning should take account of safety and security, access to goods and services, air pollution, noise, greenhouse gas emissions and energy consumption, land use, cover passenger and freight transportation and all modes of transport."³⁶ The guidance provided by the Commission on developing Sustainable Urban Transport Plans³⁷ is very useful for local governments who are already looking for solutions to the problems of urban land-use and transportation. However, without a specific obligation to draw up such a plan, many municipalities will not find the time and the money to prioritise urban transport and land-use planning. This is particularly true in those cities (particularly in new Member States) where these problems may not yet be endemic and the progress of car-based development could still be checked.

Transport planning by housing developers could be useful even if not coupled with a public transport access obligation. The Green Paper mentions in passing the possibility that "developers could be encouraged to prepare a site-specific mobility plan as part of the procedure for obtaining planning permission."³⁸ In many countries, home buyers and local authorities alike tend to neglect the transport aspects of new housing developments. As the problem is similar to buyers' neglect or ignorance of their building's energy use, the solution could be to expand building energy performance certifi-

³⁵ An example of this is the "Finger Plan" in Copenhagen, where development is restricted to the five "fingers" reaching out from the city. The fingers follow railway lines, and between the fingers, there are green areas. (see e.g., http://www.geogr.ku.dk/dkgs/image/pub.pdf/artikler/2006_2/02.pdf).

³⁶ COM (2005) 718 final, p.5.

³⁷ See footnotes 30 and 31 for links

³⁸ COM (2007) 551 final, p. 7.

cates with information on the quality of transport services available at the building (and an estimate of the CO₂ emissions caused by the trips to the building.)

Emissions trading for land-uses that cause transport emissions (e.g., parking)

It is worth considering whether the transport emissions could not be limited through involving the land-use forms that cause emissions into an emissions trading scheme. Emissions trading would be superior to benchmarks or plans as it would be able to set a cap on transport emissions without prescribing the policies that should be used to achieve it.

To date, the inclusion of transport into existing emissions trading schemes was not possible for two reasons: (a) there are so many transport vehicles that management, verification and enforcement of a scheme involving individual car operators would be very costly; (b) the operator of a car has little influence on the per-kilometre efficiency of the car, which means that the main incentive that could be provided specifically by emissions trading is ineffective (incentives to drive less or to buy more efficient cars are much easier created through fiscal measures.)

In order to make emissions trading a valid concept for transport emissions, we need to find a set of operators that are less numerous and can actively influence the CO₂-efficiency of the overall transport system. For this, we need to consider not only direct, but also indirect emitters. Such indirect emitters could be the owners of houses or other buildings, but they are just as numerous as car operators, so the system would not be much simpler. A much more appropriate set of operators are the providers of parking spaces, private or public, or on a higher level of aggregation, municipal governments. According to Southworth (2001): “*Parking control policies, through either higher parking rates or restrictions on spaces available, offer considerable leverage through which to alter travel patterns.*”

Currently, free parking in out-of-town workplaces and shopping centres is one of the infrastructural bases of the present unsustainable trend of urban sprawl. As the Green Paper on Urban Mobility says: “*Providing more parking spaces may, in the long-term encourage car transport, in particular if they are free of charge.*”³⁹ The amount of parking space is a significant limiting factor on the volume of transport, but it is often provided by private entities with no government control, thereby inducing further traffic and overloading the road network. The mechanism works in reverse as well, cars stop going to places where it is not possible to park. Therefore, controlling parking could effectively be used to control transport CO₂ emissions.

A trading scheme to reduce transport emissions involving parking place-providers would work as follows:

- (i) The government would establish a total cap on the amount of transport emissions for a given period. A quantity of allowances equal to this cap would be distributed free of charge to entities or by auction.
- (ii) Entities responsible for a large number of parking (large offices, shopping centres, municipalities, etc.) would be required to report the number of parking spaces provided, and they would be obliged to surrender a certain amount of allowances for each parking space.
- (iii) The amount of allowances to be surrendered per parking space would be set by the government in advance on the basis of average vehicle emissions, average trip lengths and aver-

age parking space occupancy rates. This figure should not be changed very often, and changes would need a long lead-time.

- (iv) The cost of providing a parking space would depend on the level of scarcity, i.e., the size of transport emissions compared to the cap. Depending on their resources, entities in the scheme would need to choose between limiting the amount of parking spaces provided and increasing the price of parking spaces for users. Thus the cost of parking would increase, but this increase would vary by parking provider, which would make the cost increases harder to resist.

It is important to realise that because parking spaces function in groups (i.e., one car needs a parking space at home, at the office and at the shopping centre to be able to operate) it is not necessary to introduce the system everywhere at the same time. The system would bring benefits even if first limited to large commercial establishments and offices (though questions of equity would arise as to whether it is fair to place the entire burden on a subset of parking space providers.) A great advantage of emissions trading for parking spaces is that there is no international competition and costs may be passed on to the consumer freely.

Beyond simply ensuring that the cap for transport emissions is not overstepped, and realising the polluter pays principle, such a scheme would have long-term structural impacts. It would eliminate the huge cost-advantages of car-only locations, which are in fact free riding on publicly funded road infrastructure and put out of business more sustainably located facilities which are reachable by public transport. In the next step, if the accessibility by car to workplaces and shopping decreases, suburban living becomes more difficult, thereby inducing people to live in more sustainable locations.

A great political advantage of an emissions trading scheme for parking spaces is that it would not directly limit mobility by increasing the price of cars or the price of fuel, which measures would be very unpopular if implemented at a level which has a real effect on CO₂ emissions. The car fetish would be left untouched, and high parking prices would develop “automatically”, without direct government involvement.

Conclusions

The statistical analysis shows that wherever sprawl occurs in the EU, it results in a strong increase of transport-related CO₂ emissions. Sprawl, measured in the increase of the areas covered by buildings and roads, is a stronger cause of increased transport emissions than other possible causes, such as the growth of per capita GDP or population growth.

This conclusion is very relevant for the EU's climate policy. Unlike other sources of greenhouse gas emissions, emissions from transport are growing steadily. Current EU policies aimed at transport emissions try to increase the CO₂-efficiency of cars, but they are not enough to stop the growth of emissions. If sprawl is the cause of increasing transport emissions, then the EU needs to adopt policies that try to limit sprawl. There are many such policy options, some of them are described in this paper (e.g., public transport access obligation, mandatory sustainable transport plans, emissions trading for parking).

Acknowledgements

The author is grateful to Ágnes Kelemen for her assistance in the regression analysis, and to Gábor Róna, Prof. Denny Ellerman, Peter

³⁹ COM (2007) 551 final, p. 6.

Zapfel and David Delcampe for the ideas, comments and corrections provided for this paper.

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